

CATALOG DOCUMENTATION
EMAP - ESTUARIES PROGRAM LEVEL DATABASE
1990 FISH SPECIES DATA

TABLE OF CONTENTS

1. DATA SET IDENTIFICATION
2. INVESTIGATOR INFORMATION
3. DATA SET ABSTRACT
4. OBJECTIVES AND INTRODUCTION
5. DATA ACQUISITION AND PROCESSING METHODS
6. DATA MANIPULATIONS
7. DATA DESCRIPTION
8. GEOGRAPHIC AND SPATIAL INFORMATION
9. QUALITY CONTROL/QUALITY ASSURANCE
10. DATA ACCESS
11. REFERENCES
12. TABLE OF ACRONYMS
13. PERSONNEL INFORMATION

1. DATA SET IDENTIFICATION

1.1 Title of Catalog Document

EMAP-Estuaries Program Level Database
1990 Virginian Province
Fish Abundance, Composition, Length and Pathology Data
Summarized for each Taxon Collected at a Station

1.2 Authors of the Catalog entry

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1.3 Catalog revision date

5 April 1996

1.4 Data set name

FISHSPEC

1.5 Task Group

Estuaries

1.6 Data set identification code

00006

1.7 Version

001

1.8 Requested Acknowledgment

If you plan to publish these data in any way, EPA requires a standard statement for work it has supported:

"Although the data described in this article have been funded wholly or in part by the U. S. Environmental Protection Agency through its EMAP-Estuaries Program, it has not been subjected to Agency review, and therefore does not necessarily reflect the views of the Agency and no official endorsement should be inferred."

2. INVESTIGATOR INFORMATION

2.1 Principal Investigator

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2.2. Investigation Participant-Sample Collection

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3. DATA SET ABSTRACT

3.1 Abstract of the Data Set

The Fish Species data set is a synopsis of one successful standard trawl conducted at a station. The total count of individuals of each fish taxon caught in the standard trawl is reported. The length (mm) of up to 30 individuals caught in a standard trawl was measured, according to protocol. If there were two or more individuals of a taxon, the mean length and standard deviation of the mean were calculated. The length is reported for an individual. A count of pathologies observed on all individuals of a taxon may be summarized for up to four (4) categories: body, ocular, branchial and buccal. Each taxon is identified by a unique code which can be cross-referenced to the taxon phylogeny.

3.2 Keywords for the Data Set

Species abundance, species composition, species mean length, taxon abundance, body pathology, branchial pathology, buccal pathology, ocular pathology

4. OBJECTIVES AND INTRODUCTION

4.1 Project and Investigation Objective

The Environmental Monitoring and Assessment Program (EMAP) was designed to periodically estimate the status and trends of the Nation's ecological resources on a regional basis. EMAP provides a strategy to identify and bound the extent, magnitude and location of environmental degradation and improvement on a regional scale based on randomly located station sites.

4.2 Data Set Objective

The objective of the Fish Species data set was to collect information to characterize fish assemblages in the estuaries of the Virginian Provinces. Only the randomly located Base Sampling Sites (BASE) are included in this data set.

3.3 Background Discussion

Estuarine fish have economic, recreational, and ecological value. Some are harvested; others serve as forage for predatory organisms that have great aesthetic value (e.g., birds, sport fish, mammals). Most fish species hold a position near the top of the food chain. The impact of anthropogenic activities on fish concerns the public.

There are several advantages to using fish as potential indicators of estuarine condition. Because of their longevity and dominant position at the upper end of the food web, fish responses integrate many short-term and small-scale environmental perturbations. Fish are known to respond to most of the major environmental perturbations of concern in estuaries, including eutrophication, habitat modification and pathogenic or toxic contamination. Eutrophication can affect fish adversely by reducing dissolved oxygen below levels that are critical for growth or survival. Habitat modification, such as the loss of submerged aquatic vegetation, has been linked to decreased fish productivity through loss of important nursery areas. Toxic and pathogenic contaminants can decrease fish growth, reproduction or survival and can make fish unsafe for human consumption. Fish also are valuable as indicators because of their importance for determining the public perception of estuarine quality.

Factors controlling species composition and abundance of estuarine fish communities are complex and not well understood. However, most fish ecologists agree that the assemblage of fish that occurs at a sampling site is affected by water and sediment quality parameters, including

contaminant concentrations and inputs, and habitat conditions. For example, polluted sites are thought to contain less diverse and less stable fish assemblages than unpolluted sites and are dominated by pollution-tolerant species, such as mummichogs and carp. The degree to which information on fish community composition can be used to assess the status of estuarine environments on regional scales is unknown. A major purpose of evaluating fish community composition was to determine whether regional scale information on fish community characteristics could be used as indicator of environmental quality. If fish community data could be used in this manner, it would be particularly meaningful to a broad range of audiences, especially the public.

The incidence of gross pathological disorders in fish such as fin erosion, somatic ulcers, cataracts, and axial skeletal "aesthetic" abnormalities is a major means used by the public to judge the environmental quality of a water body. Gross pathological disorders have a scientific base; severely polluted habitats have a higher frequency of gross pathological disorders than similar, less polluted habitats. Laboratory exposures to contaminants such as PCBs, petroleum products, and pesticides, also suggest that many gross pathological disorders are associated with contaminant exposure.

4.4 Summary of Data Set Parameters

The raw data for species composition, abundance and length were recorded in the field after the completion of one successful standard trawl. Fish observed by the field crews to have one or more gross external pathologies were processed for laboratory examination.

5. DATA ACQUISITION AND PROCESSING METHODS

5.1 Data Acquisition

5.1.1 Sampling Objective

Conduct one (1) successful standard fish trawl at a BASE Sampling Site suitable for the characterization of fish species composition, abundance, length and occurrence of gross external pathologies.

5.1.2 Sample Collection Method Summary

A fish trawl is a funnel-shaped net that filters fish from the near bottom waters. Fish are herded by ground wire and doors into the mouth of the funnel where fish were captured. Fish are prevented from escaping over the top panel of the trawl by an overhanging panel. The net was towed for 10 + 2 minutes with a towing speed of 2-3 knots through the water against the prevailing current. Speed over the bottom was 1-3 knots.

All fish in the net were sorted by species and enumerated. All species considered to be rare, threatened, or endangered were processed immediately and released alive. Thirty individuals of a fish species (or all individuals if less than

30 were caught) were measured (fork length) to the nearest millimeter.

As fish were measured, specimens greater than 75 mm in fork length were examined for evidence of gross pathological conditions. While fish were still alive or freshly dead, the skin, fins, eyes, and branchial chambers were inspected for evidence of disease. Abnormalities were noted on a data sheet. Fish with abnormalities were saved and preserved for histopathological analysis. The entire length of the abdominal cavity of pathology fish samples was carefully opened without injuring the visceral organs to allow proper preservation of the sample. If an external growth was present, it was measured and sliced open with one clean cut using a sharp razor blade. Either the entire fish (fish less than 15 cm) or the head, visceral cavity, and organs (fish over 15 cm total length) was placed in a perforated plastic bag. The bag was then placed in a bucket containing Dietrich's fixative. Reference (non-diseased) fish were also collected at some stations and processed as pathology samples.

All fish species were examined for evidence of gross external pathologies. For fish with pathologies, one or two cuts were made through the livers of specimens larger than 15 cm and opercula were removed prior to immersion in fixative.

5.1.3 Beginning Sampling Date

19 July 1990

5.1.4 Ending Sampling Date

30 September 1990

5.1.5 Platform

Sampling was conducted from 8 m (24 ft), twin-engine Chesapeake style work boats.

5.1.6 Sampling Equipment

The trawl net was a funnel-shaped high rise sampling trawl with a 16-meter footrope with a chain sweep. The trawl net had 5 cm mesh wings and a 2.5 cm cod end.

5.1.7 Manufacturer of Equipment

Not Applicable

5.1.8 Key Variables

The total count of individuals of a taxon collected at a station, species identification information, individual length and occurrence of gross external pathologies were recorded after sample collection.

5.1.9 Collection Method Calibration

The sampling gear did not require calibration. It required inspection for tears and proper assemblage.

5.1.10 Collection Quality Control

A trawl was considered void if one or more of the following conditions occurred:

1. A tow could not be completed because of hangdown, boat malfunction, vessel traffic, or major disruption of gear. However, a tow was considered acceptable if it was necessary to retrieve the net after at least eight minutes due to impending hazards, as long as the net was retrieved in the standard manner.
2. Boat speed or speed over the bottom was beyond the prescribed, acceptable range.
3. The cod-end of the net was not tied shut.
4. The trawl continued for more than twelve minutes or less than eight minutes.
5. The net was filled with mud or debris.
6. A portion of the catch was lost prior to processing.
7. The tow wire, bridle, headrope, footrope, or up and down lines parted.
8. The net was torn in a way that may have significantly altered the efficiency of the net.

If, due to repeated snags, a successful trawl could not be performed within 1½ hours of starting, no further attempts were made and the Field Operations Center was notified.

Quality assurance audits were performed by qualified personnel to verify the enumeration of fish by the field crews. The accuracy goal for the fish abundance data was that the original results and the results of the field QA audit should agree within ten percent. In addition, the first one or two individual fish caught of any species were sent to the laboratory for taxonomic verification. All fish species should have been correctly identified. If these goals were not met, corrective actions included re-training the field crew and flagging the previous data from that crew for those species which had been misidentified. A random subset of the fish measured in the field was set aside for duplicate measurements by a second technician. The acceptable error in this procedure was + 5 mm. If this re-measurement procedure could not be followed due to logistical constraints, then quality assurance documentation of fish length was accomplished during field auditing.

The first two individuals of each species collected (except threatened or endangered species) were preserved and returned

to ERL-N for expert identification. Fish sent in were preserved for the EMAP fish reference collection to be used for future training. If corrections to the fish data base were necessary due to the mis-identification of a species, these corrections were carefully documented. Field crews were also notified of their misidentification to avoid any further ID problems for that species.

The quality assurance audits also included verification of the observation and enumeration of gross external pathologies on fish over 75 mm by the field crews. The quality of fixation techniques for fish pathology samples was also verified during the field QA audits and by the receiving laboratory.

5.1.11 Sample Collection Method Reference

Strobel, C.J. 1990. Environmental Monitoring and Assessment Program-Near Coastal: 1990 Demonstration Project Field Operations Manual. U.S. EPA NHEERL-AED, Narragansett, RI. October 1990.

5.2 Data Preparation and Sample Processing

5.2.1 Sample Processing Objective

Process specimens for presence of gross external pathologies.

5.2.2 Sample Processing Methods Summary

Fish pathology specimens were subjected to a critical gross external examination. The presence or absence of many types of body surface and fin gross pathologies, including body lumps, growths, and ulcerations and fin erosion, was noted.

5.2.3 Sample Processing Method Calibration

NA

5.2.4 Sample Processing Quality Control

Pathology fish samples sent to the analytical laboratory were subjected to a critical gross examination. The findings of this examination were compared to the findings from the field examination.

The quality of fixation techniques for fish pathology samples was verified during field QA audits and by the receiving laboratory.

5.2.5 Sample Processing Method Reference

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008.

6. DATA MANIPULATIONS

6.1 Name of New of Modified Values

REP_NUM	Trawl Replicate Number
FSPECABN	Taxon Abundance (#/sample)
FSPEC_MM	Mean Length (mm) of Ind. of the Taxon
FSPECSTD	Standard Dev. of Length (mm)
FSPECBOD	# Body Path. on Ind. of the Taxon
FSPECBRN	# Branchial Path. on Ind. of the Taxon
FSPECBUC	# Buccal Path. on Ind. of the Taxon
FSPECOCU	# Eye Path. on Ind. of the Taxon

6.2 Data Manipulation Description

Count of trawl number
Count of total individuals of a taxon collected at a station
Mean length (mm) of each taxon collected at a station
Standard deviation of the mean length
Count of total pathologies on all individuals of a taxon collected at a station

6.3 Data Manipulation Examples

FSPEC_MM (Mean Length of all Individuals of a Taxon) =
Sum of all lengths of a taxon / total number of individuals of a taxon

FSPECSTD (Standard Deviation of the Mean Length) =
The standard deviation was calculated when there was more than one length for a taxon

FSPECBOD FSPECBRN FSPECBUC FSPECOCU
All pathologies on all individuals of a taxon collected at a station were summed

7. DATA DESCRIPTION

7.1 Description of Parameters

Parameter #	SAS Name	Data Type	Len	Format	Parameter Label
1	STA_NAME	Char	8	8.	The Station Identifier
2	VST_DATE	Num	8	YYMMDD6.	The Date the Sample was Collected
3	REP_NUM	Num	8	2.	Nekton Trawl Replicate Number
4	SPECCODE	Char	8	\$8.	EMAP Taxon Code
5	FSPECABN	Num	8	4.	Taxon Abundance (#/sample)
6	FSPEC_MM	Num	8	6.1	Mean Length (mm) of Ind. of the Taxon
7	FSPECSTD	Num	8	6.1	Standard Dev. of Length (mm)
8	FSPECBOD	Num	8	4.	# Body Path. on Ind. of the Taxon
9	FSPECBRN	Num	8	4.	# Branchial Path. on Ind. of the Taxon
10	FSPECBUC	Num	8	4.	# Buccal Path. on Ind. of the Taxon
11	FSPECOCU	Num	8	4.	# Eye Path. on Ind. of the Taxon

7.1.6 Precision to which values are reported

Total abundance is reported as a whole number.

Mean abundance and standard deviation (SD) are reported to 1 decimal place.

Pathology values are reported to a whole number.

7.1.7 Minimum Value in Data Set

REP_NUM	1
FSPECABN	0
FSPEC_MM	39.7
FSPECSTD	0
FSPECBOD	0
FSPECBRN	0
FSPECBUC	0
FSPECOCU	0

7.1.8 Maximum Value in Data Set

REP_NUM	1
FSPECABN	580
FSPEC_MM	610.0
FSPECSTD	145.7
FSPECBOD	10
FSPECBRN	3
FSPECBUC	2
FSPECOCU	4

7.2 Data Record Example

7.2.1 Column Names for Example Records

STA_NAME	VST_DATE	REP_NUM	SPECCODE	FSPECABN	FSPEC_MM
FSPECSTD	FSPECBOD	FSPECBRN	FSPECBUC	FSPECOCU	

7.2.2 Example Data Records

OBS	STA_NAME	VST_DATE	REP_NUM	SPECCODE	FSPECABN	FSPEC_MM	FSPECSTD
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1	VA90-021	.	1	NOSAMPLE	.	.	.
2	VA90-022	900723	1	CLUPHARE	9	95.8	14.5
3	VA90-022	900723	1	PARAOBLO	3	243.3	10.6
4	VA90-022	900723	1	PLEUAMER	3	175.0	26.9
5	VA90-022	900723	1	SCOPAQUO	3	148.3	7.4

OBS	FSPECBOD	FSPECBRN	FSPECBUC	FSPECOCU
-----	----------	----------	----------	----------

1
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0

8. GEOGRAPHIC AND SPATIAL INFORMATION

8.1 Minimum Longitude

-77 Degrees 17 Minutes 4.80 Decimal Seconds

8.2 Maximum Longitude

-70 Degrees 04 Minutes 18.60 Decimal Seconds

8.3 Minimum Latitude

36 Degrees 49 Minutes 54.60 Decimal Seconds

8.4 Maximum Latitude

41 Degrees 38 Minutes 33.00 Decimal Seconds

8.5 Name of area or region

Virginian Province

Stations were located in estuaries along the East Coast of the United States from Cape Cod, Massachusetts, to Cape Henry, Virginia, at the mouth of the Chesapeake Bay. The area includes the District of Columbia and the States of Virginia, Maryland, New Jersey, Delaware, Pennsylvania, New York, Connecticut, Rhode Island and Massachusetts.

9. QUALITY CONTROL/QUALITY ASSURANCE

9.1 Measurement Quality Objectives

Measurement quality objectives were outlined in the Quality Assurance Project Plan (Valente et al, 1990). Accuracy and precision goals are outlined below:

Fish Community Composition	Accuracy Goal	Completeness Goal
Counting	10 %	90 %
Taxonomic Identification	10 %	90 %
Length Determinations	+ 5 mm	90 %

9.2 Quality Assurance/Control Methods

Data from trawls which did not meet the requirements of a standard trawl were not included in this data set.

To further validate the identification of fish species, range checks were performed for species in the data base to assure that fish captured at a given station met certain criteria:

Salinity: For each station, bottom salinity was determined from the CTD cast and compared to the expected salinity range

(based on historic data) for each species of fish captured at that station. Species records falling out of the salinity range were flagged.

Species location: A latitude range for each species captured by EMAP field crews was established based on historic data and fish keys. Each system that a particular species occurred in was compared to that range to determine inclusion. Latitudes where fish were reported captured were compared to expected latitudes for that species and flagged if there were discrepancies.

Length: Maximum length for each species was determined from fish keys. A QA length was calculated as 50% of the maximum length and outliers were flagged. Flagged data records were then investigated on a case by case basis to determine the cause of discrepancy and recommend a course of action.

To verify each crew's ability to properly identify pathologies, fish identified as having an external pathology by the field crews were shipped to ERL-Gulf Breeze (1990) for verification by the laboratory's pathologist. It is important to note that this verification was "blind" (i.e., the pathologist did not know which fish the field crews believed to have a pathology). This provided an estimate of the percentage of "false positives". In addition, in order to develop an estimate of the rate of "false negatives" (i.e., number of pathologies missed, therefore never sent in for verification), crews collected and shipped up to 25 individuals of each target species and 10 from any other species (which they determined to be free from external pathologies) caught at Indicator Testing and Evaluation stations. These steps were necessary because fish were also collected for chemical residue analysis, which took priority over pathology QA. Because of this, a fish observed by the crew to have a pathology may have been sent in for chemical analysis rather than pathology verification. Therefore, the assessment produced by EMAP on the prevalence of gross external pathologies in fish is based on field observations, not laboratory observations. An error rate is then associated with these data based on the results of the QA review.

Following a review of the 1990 and 1991 pathology QA data, and in consultation with experts from NMFS, EMAP-VP elected to condense field observations for fish pathologies to four basic categories: lumps, growths, ulcerations, and fin erosion. It was hoped that by making the examination more simple the success rate (i.e., proper identification) would increase.

No laboratory audits were conducted for these indicators. Field performance reviews and audits were conducted as described in Section 2. The QA Coordinator or Field Coordinator visited each crew both during trial runs and the field season. One activity observed by the reviewer was the measurement process, with the reviewer remeasuring selected fish. The reviewer also observed and checked the examination for pathologies conducted by the crew.

9.3 Quality Assessment Results

To verify each crew's ability to correctly identify fish species for the community structure indicator, the first individual of each species collected by each crew was shipped to ERL-N or Versar for verification by an expert taxonomist.

Three types of errors were detected: misspelled or incomplete species names (in the database), misidentifications, and fish that could not be identified in the field. Errors falling into the first category were easily detected, corrected in the database, and documented. An example of this type of error can be found looking at the "Atlantic tomcod". Records were received from the field for "Atlantic tomcod", "tomcod", and "tom cod" (two words). Each was listed by the computer as separate species.

The second type of error was mis-identifications. Of the 136 fish sent in for taxonomic verification, nine were misidentified, representing seven species. In all cases the crew identified a closely-related species, such as longspine porgy instead of scup, brown bullhead catfish instead of the yellow bullhead, and lizardfish instead of inshore lizardfish. An additional 16 individuals (12 species) were sent in as unknowns or partial unknowns (e.g., herring uncl.).

All errors were corrected in the database. If a QA fish was misidentified by the crew, all other fish in the same size class of that species from the same trawl were changed to the correct ID.

Results of laboratory pathology examinations reveal that the crews were generally conservative, classifying "borderline" conditions as pathologies so the fish would be examined by an expert rather than being discarded. Table 9-3 presents results of the laboratory review for the four final pathology categories EMAP-VP selected for continued use.

Table 9-3. 1990 Pathology QA results based on laboratory examination of fish crews believed to have a pathology and reference, "pathology-free" fish (n=769).

Pathology Type	False Positives ¹	False Negatives ²
Body Ulcerations	9/20 (45.0%)	8/749 (1.1%)
Body Lumps/Growths	3/12 (25.0%)	26/757 (3.4%)
Fin Erosion	8/17 (47.1%)	16/752 (2.1%)

- 1 False Positives: The denominator in this column is the total number of fish identified by the field crews as having a given pathology. The numerator is the number of these fish for which the pathology was not confirmed by the pathologist.
- 2 False Negatives: The denominator in this column is the total number of fish identified by the field crews as not having a given pathology. The numerator is the number of these fish for which the pathology was observed by the pathologist.

10. DATA ACCESS

10.1 Data Access Procedures

Data can be downloaded from the WWW server.

10.2 Data Access Restrictions

10.3 Data Access Contact Persons

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10.4 Data Set Format

Data can be downloaded in several formats from the web application and web site.

10.5 Information Concerning Anonymous FTP

Not accessible

10.6 Information Concerning WWW

Data can be downloaded from the WWW server.

10.7 EMAP CD-ROM Containing the Data Set

Data not available on CD-ROM.

11. REFERENCES

- Holland, A.F., ed. 1990. Near Coastal Program Plan for 1990: Estuaries. EPA 600/4-90/033. U.S. EPA, Office of Research and Development, NHEERL-AED, Narragansett, RI. November 1990.
- Strobel, C.J. 1990. Environmental Monitoring and Assessment Program-Near Coastal Component: 1990 Demonstration Project Field Operations Manual. U.S. EPA, Office of Research and Development, NHEERL-AED, Narragansett, RI. October 1990.
- Strobel, C.J. and R. M. Valente. 1995. Quality Assurance Report: EMAP-Virginian Province, 1990-1993. U.S. EPA, NHEERL-AED, Narragansett, RI. September 1995. EPA/620/R-95/007.
- U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008.

Valente, R.M., C.J. Strobel, J.E. Pollard, K.M. Peres, T.C. Chiang and J.R. Rosen. 1990. Environmental Monitoring and Assessment Program Near Coastal Demonstration Project Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-AED, Narragansett, RI.

Weisberg, S.B., J.B. Frithsen, A.F. Holland, J.F. Paul, K.J. Scott, J.K. Summers, H.T. Wilson, R. Valente, D.G. Heimbuch, J. Gerritsen, S.C. Schimmel and R.W. Latimer. 1993. EMAP - Estuaries Virginian Province 1990 Demonstration Project Report. EPA 620/R-93/006. U.S. Environmental Protection Agency, NHEERL-AED, Narragansett, RI 02882-1197.

12. TABLE OF ACRONYMS

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